PHYS 600 003: Fields, disorder, and dynamics in condensed matter physics

Instructor: Matthew Foster, BRK 303, matthew.foster@rice.edu, ext. 3922
Lectures: 10:00-10:50 AM M.W.F.

Textbook: There will be no required textbook. Some material will be drawn from research papers and reviews. Possibly useful references include

- Field theory and disorder:
  Quantum Field Theory and Critical Phenomena J. Zinn-Justin,
  Condensed Matter Field Theory, Altland and Simons

- Bosonization:
  Quantum Field Theory in Condensed Matter Physics, A. M. Tsvelik,
  Quantum Physics in One Dimension, T. Giamarchi,
  Conformal Field Theory, P. Francesco, P. Mathieu, and D. Senechal

(Approximate) Syllabus

1. Introduction to disorder: classical random magnets
   - Random Ising chain, typical vs. average properties
   - Random paramagnet
   - Random energy model and the glass transition
2. Quantum disordered systems
   - Review of second quantization, Gaussian integrals
   - Random matrix theory classification of dirty quantum systems
   - Stability of the Anderson insulator, locator expansion in 1D
   - Scaling theory phenomenology
   - Non-linear sigma model, renormalization group
   - Dirty Dirac fermions and topological surface states
3. Strong quantum effects in low dimensions: Bosonization
   - Field theoretic bosonization
   - Heisenberg chain, sine Gordon and massless Thirring models, scaling, local operators, KT transition
   - Applications to disordered fermions in 2D
   - Applications to quench dynamics in 1+1-D
4. Current algebras in condensed matter
   - Abelian bosonization again: Kac-Moody Ward identity, primary fields
   - Non-abelian basics, $SU(2)_k$
   - Heisenberg spin chain; dirty Dirac fermions

Grading: Homework 2-4 sets (50%), short paper and presentation on a research topic at the end of the course (50%).

Prerequisites: This is an advanced graduate course on theoretical methods and research topics of current interest. Required prerequisites are graduate level quantum mechanics and statistical mechanics, and undergraduate solid state physics. Previous exposure to field theory methods (condensed matter or high energy) is helpful but not required. Since this is a seminar course, there will be some flexibility in the pace.

Any student with a documented disability needing academic adjustments or accommodations is requested to speak with me during the first week of class. Additionally, students will need to contact Disability Support Services in the Allen Center.